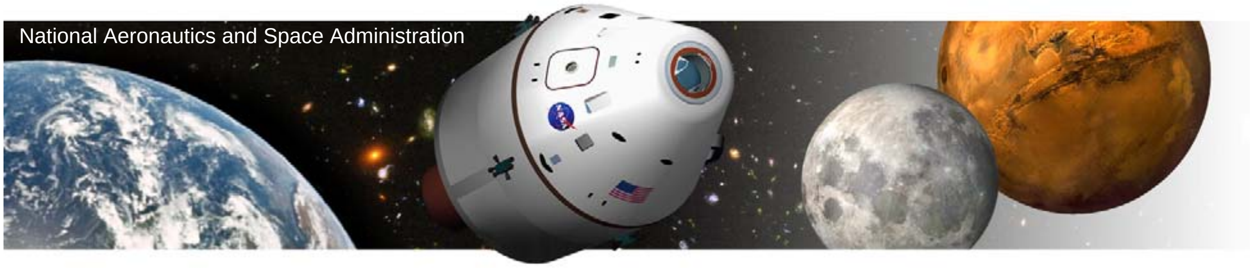

Flipping Lunar-tics and Their Electrifying Moves!

9-12 National Science Standards - Key Concept(s):
Physical Science, Science and Technology – Newton's Laws of Motion, Electricity, Technological Design

Purpose:
NASA is returning to the Moon to explore where people have never been. After making new discoveries during work hours, perhaps astronauts will give winter sports a try in their free time. Read more to learn how snowboard maneuvers and traveling to the Moon are similar and how spacesuit gloves compare to your winter gear (Physics, Math, Technology).

Featured Imagery Component:
http://brainbites.nasa.gov/snowboarder

Educator Insights:

Motion:

1. Olympic half pipe snowboarders are not the only people getting off the ground, taking flight, and steadying themselves for safe, "feet first" landings these days. NASA is going back to the Moon and will make a number of "feet first" landings on its powdery gray surface. While snowboarders and lunar lander pilots may seem very different at first, a number of similarities exist. Yes, flipping snowboarders and lunar explorers all have fun at work, and they also take advantage of the same scientific principles along the way.

   For instance, just after a snowboarder launches herself from a half pipe, Sir Isaac Newton's first law of motion tends to keep her moving in the same direction. It is Newton's second law of motion that changes her course and brings her back to Earth again a few seconds later. Similarly, when astronauts return to the Moon in NASA's new Crew Exploration Vehicle (CEV), Newton's first law of motion would keep them moving in one direction as they coast towards the Moon. However, like the snowboarder that is pulled back to Earth by gravity, it is Newton's second law that governs how the gravity of both the Earth and Moon work together to guide the CEV to a location where it can perform its Lunar Orbit Insertion (LOI) engine firing. By the way, it is Newton's third law of motion that kicks in each time the CEV's thrusters are fired.

2. After completing the LOI burn the CEV will enter a "parking orbit" around the Moon. This 100 km circular parking orbit could be at a speed of nearly 1633 m/s relative to the Moon's surface (speed and altitude are always relative, just ask a snowboarder). One purpose of a parking orbit is to provide the capability to reach various lunar landing sites with only small changes in the amount of energy required to complete the mission. If the parking orbit requires a special orientation, energy requirements for that mission could significantly increase. By having the option to land nearly anywhere on the Moon, NASA will be able to explore the polar regions that the Apollo missions could not access. It is in the depths of always-shaded craters at the Moon's polar regions where NASA scientists believe they have the best chance of discovering lunar ice, if any exists. This could be the first step towards snowboarding on the Moon.

   Once a landing site is chosen, the lunar lander will execute two burns to make its powered descent to the lunar surface. The first of these burns is a small (19 m/s) deorbit burn. This first burn sets up the lunar lander for the second burn, which is also known as the Powered Descent Initiation (PDI). The time between the first deorbit burn and PDI would be about 56 minutes and over the course of this time the lunar lander would complete a half of an orbit around the Moon.

   After PDI, the powered descent unfolds over three stages, as shown in Figure 1. These are known as the braking stage, the pitchup/throttledown stage, and the vertical landing stage. Unlike a snowboarder, NASA's spacecraft have

rockets to control their *attitude* or three-dimensional orientation in space. What airborne boarders and lunar landers *do* have in common is that they both must control their rotation rates in flight in order to ensure they make safe and graceful landings. Although the spacecraft are still being designed, NASA trajectory experts indicate that the CEV's lunar lander could have a 60 second pitchup/throttledown phase during which a 1.3º/second pitch rate would be used to upright the lander as shown in Figure 1. Be sure to watch the Olympic snowboarding half pipe events to estimate the rotation rates snowboarders use during their un-powered descents to Earth. The results could be dizzying.

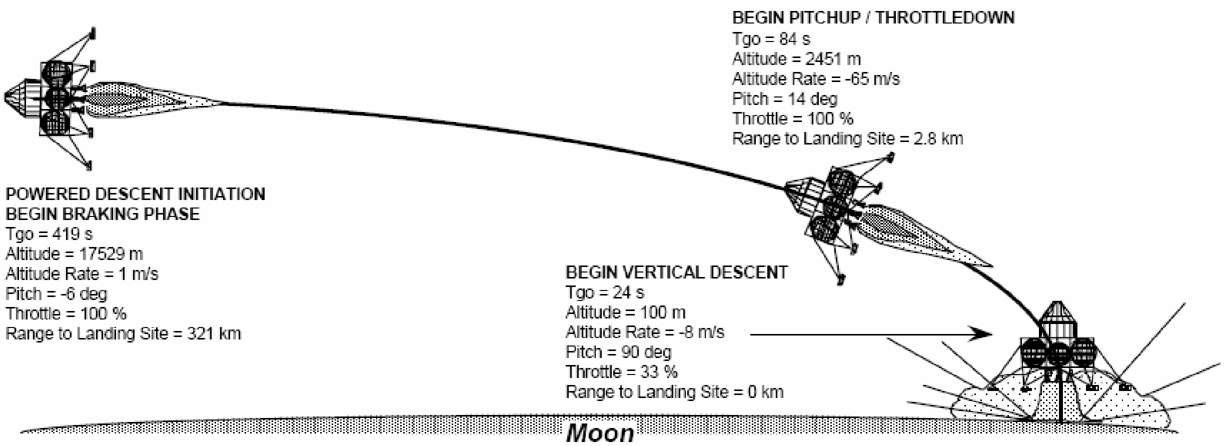

Figure 1. Possible final descent sequence for lunar landing

Electricity & Technology:

3. Just as Olympic snowboarders wear gloves for protection while competing, astronauts must wear gloves to protect themselves from vacuum while on spacewalks or when exploring the Moon. NASA's gloves have 3 primary layers. From the outside in is the Thermal Micrometeoroid protection Garment (TMG), the Restraint, and the Bladder. The TMG provides thermal insulation and some protection against micro meteoroids / orbital debris. The Restraint carries the internal pressure loads and uses hard surfaces to improve hand mobility. Finally, the Bladder is the layer that keeps the suit sealed and prevents precious oxygen from escaping.

4. In addition to maintaining pressure, NASA's spacesuit gloves also work to keep astronauts' hands warm – just like gloves for winter sports. Unlike ordinary gloves, NASA's contain heaters that are tacked to the inner surface of the TMG. These heaters are purposely placed outside the suit's Bladder because any sort of spark or short circuit in the pure oxygen environment could start a fire. For this reason, there is only one electrical harness inside the Bladder and it is used to carry only very low powered signals. One of the signals carries biomedical information (basically heart rate data) to the radio to be transmitted to flight surgeons in Houston's Mission Control Center. The other signal simply carries voice communication signals between the astronaut and his radio.

5. The heaters in spacesuit gloves, along with the ERCA (Extravehicular mobility unit Radio frequency Camera Assembly) or "helmet camera" are powered by the Rechargeable Extravehicular Battery Assembly (REBA). The REBA is designed to provide 12.5 +/- 1.5 volts from 50 small rechargeable Nickel Metal Hydride (NiMH) batteries. Between the REBA and the heaters is another important component called the In-Line Cable Voltage Regulator (ILCVR). The ILCVR reduces the 12 volt source down to 9 volts for the glove heaters, whereas the ERCA requires 12 volts. Given that the gloves' heaters have a resistance of 57.7 +/- 2.9 ohms and a nominal voltage of 9 volts, challenge your students to calculate the nominal current drawn by the glove heaters (~0.156 amperes). Remind them that voltage, **V**, is related to current, **I**, and resistance, **R**, through the equation $\mathbf{V} = \mathbf{I}*\mathbf{R}$. Similarly, consider having them calculate the power, **P**, consumed by the glove's heaters using the relationship $\mathbf{P} = \mathbf{I}*\mathbf{V} = \mathbf{I}^2*\mathbf{R}$ (~1.4 watts).